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[54] **DIESEL FUEL INJECTION NOZZLE**

[75] Inventors: **Ippei Horino; Yuzo Tsumura; Masatoshi Iwata,** all of Oyama, Japan

[73] Assignee: **Kabushiki Kaisha Komatsu Seisakusho,** Tokyo, Japan

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[3] **F02M 61/04**

[52] **U.S. Cl.** **239/91;** 123/532; 239/95; 239/406; 239/409

[58] **Field of Search** 123/531, 532, 294; 239/87–89, 91, 93–95, 407–411, 405, 406

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Primary Examiner—Andres Kashnikow
Attorney, Agent, or Firm—Armstrong, Nikaido, Marmelstein & Kubovcik

[57] **ABSTRACT**

A nozzle for the air injection of fuel into the combustion chamber of a diesel engine cylinder. Included is a plunger reciprocably mounted in a nozzle body to define an air chamber for receiving compressed air from the combustion chamber during the compression stroke of the piston in the engine cylinder. Formed integral with the plunger, a needle valve defines within the nozzle body a fuel chamber for receiving fuel to be injected. A nozzle tip secured to the nozzle body founds a premixing chamber open directly to the combustion chamber and further in communication with both air chamber and fuel chamber. Thus, upon descent of the plunger at the end of the compression stroke, the fuel from the fuel chamber is intimately premixed in the premixing chamber with the compressed air from the air chamber, prior to introduction into the combustion chamber.

8 Claims, 4 Drawing Figures

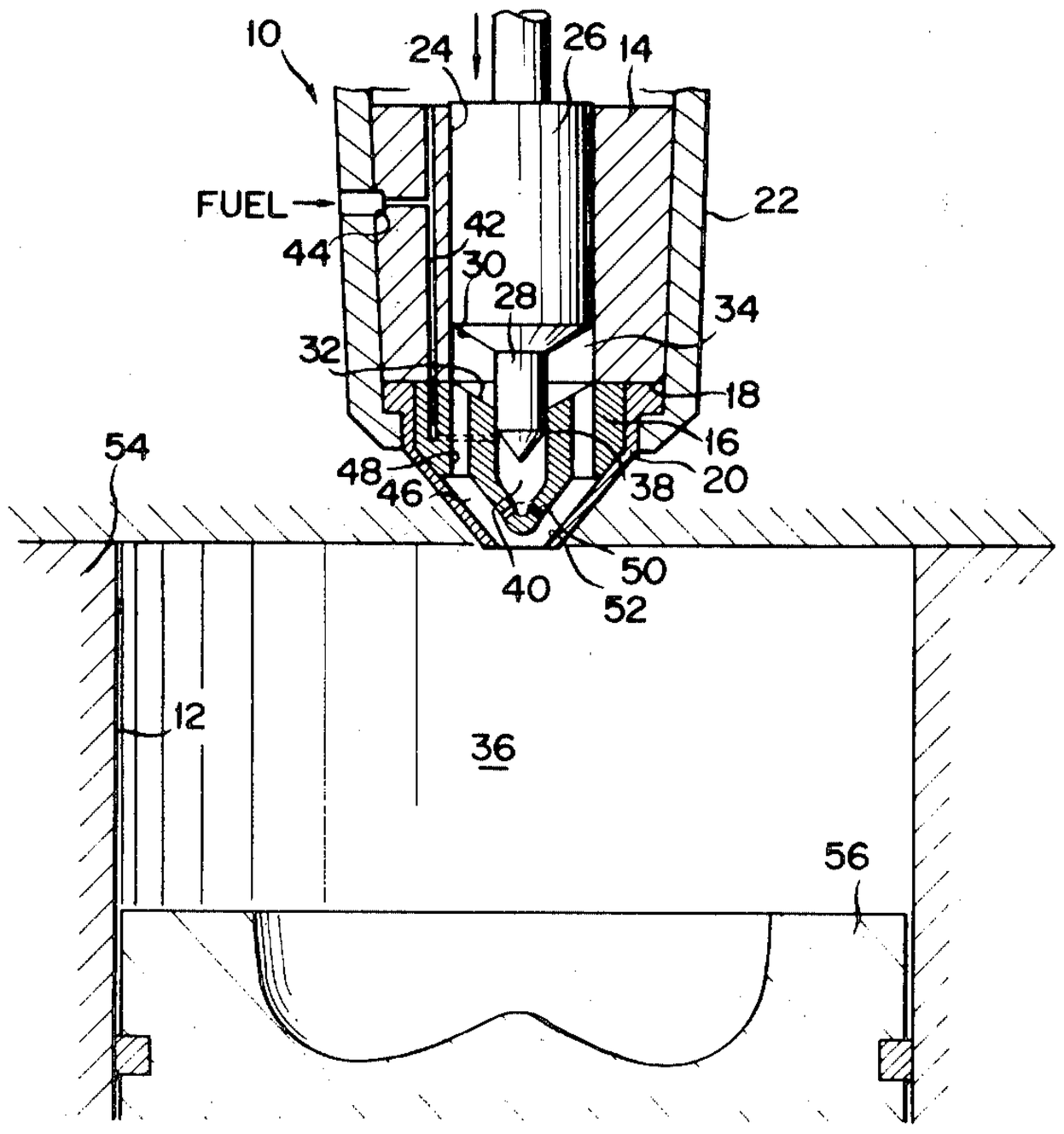

FIG. 1

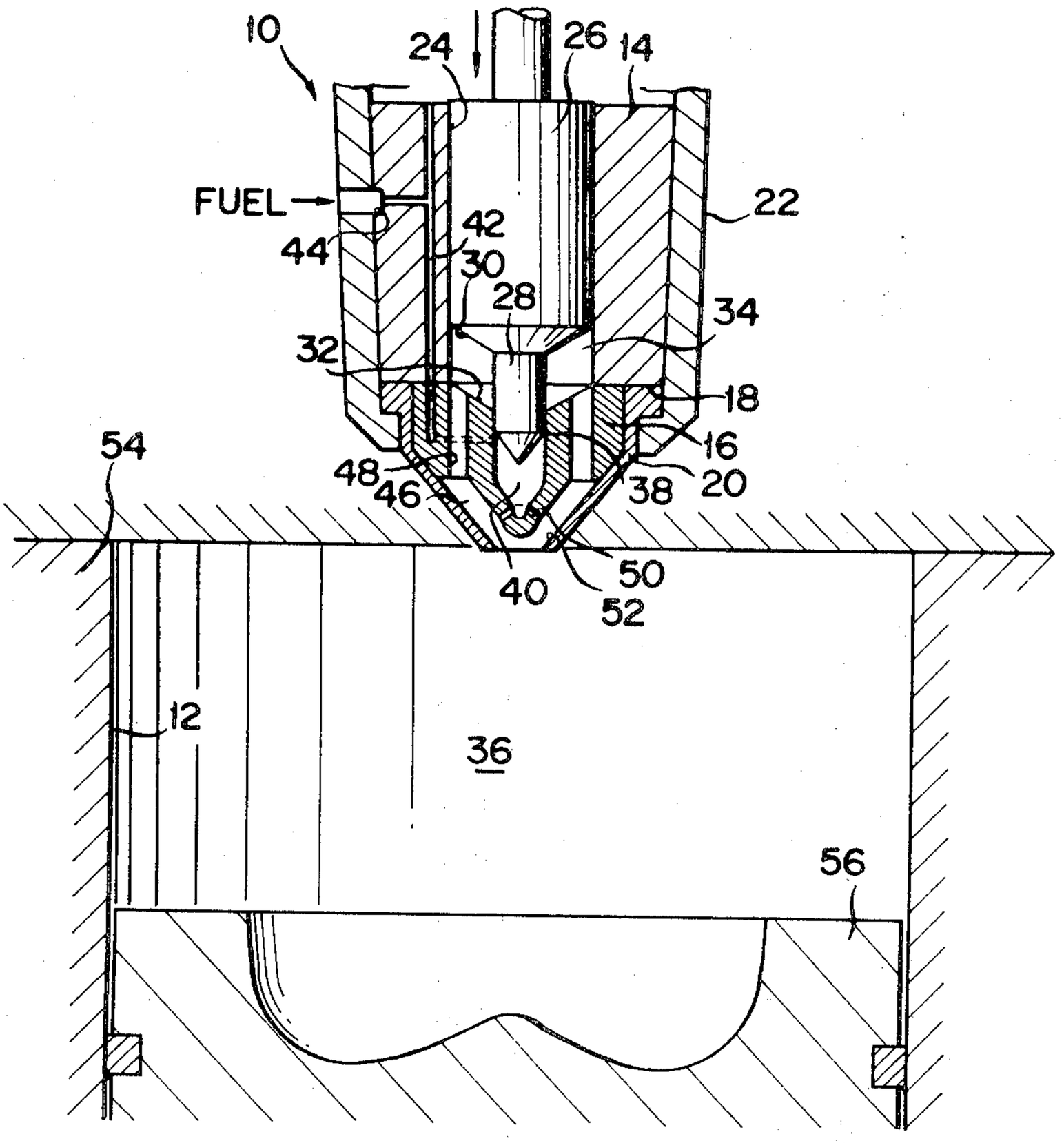
10
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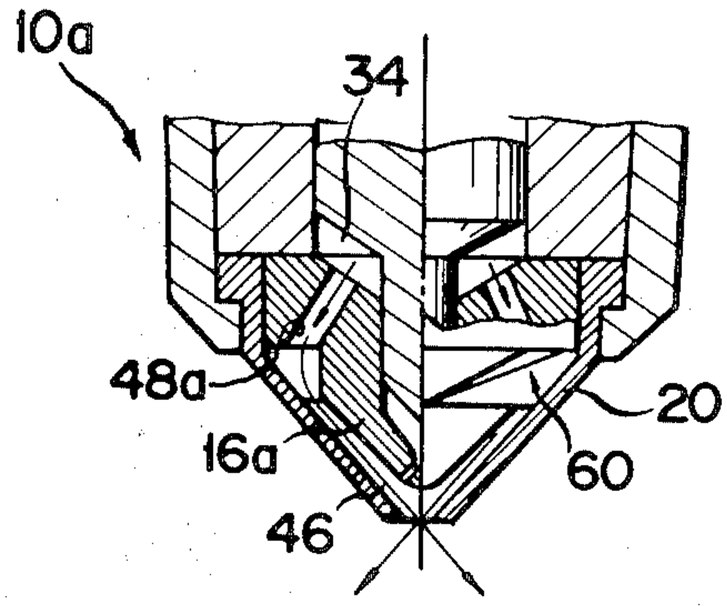
FIG. 2



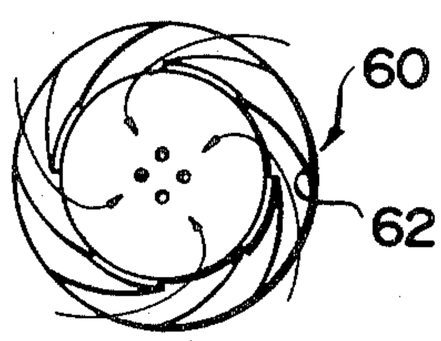
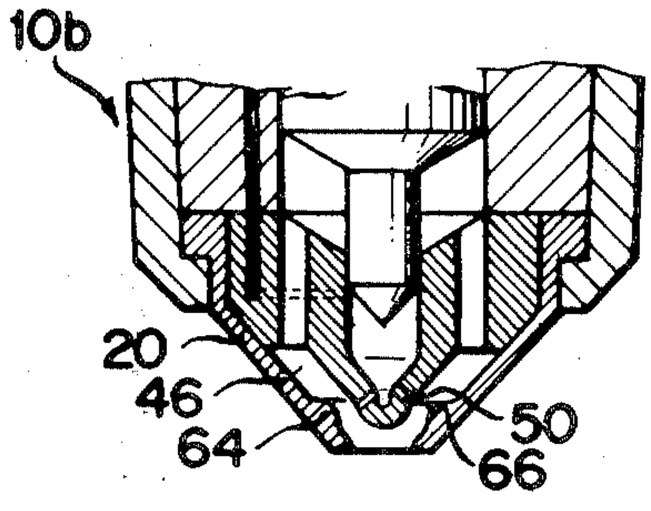


FIG. 3

FIG. 4



DIESEL FUEL INJECTION NOZZLE

BACKGROUND OF THE INVENTION

This invention relates to engine fuel injection equipment in general and, in particular, to a fuel injection nozzle for atomizing and spraying each metered charge of fuel, premixed with air, into the combustion chamber of a diesel engine cylinder.

Some early diesel engines employed an air-injection system, such that the fuel was atomized into the cylinder under air pressure. Although the system admittedly provided excellent smokefree combustion, it required expensive and bulky multistage compressors and intercoolers for injection air. Consequently, with the advent of spray nozzles capable of sufficiently atomizing the fuel by use of fuel pressure alone, the solid or airless injection has become the generally accepted method of fuel injection in compression-ignition engines.

Recently, however, it is being contemplated to inject fuel into diesel engine cylinders at pressures in the order of 1000 kgf/cm^2, with a view to higher engine efficiency and minimal exhaustion of air pollutants. The usual airless injection method does not necessarily provide good combustion at such ultrahigh pressures.

SUMMARY OF THE INVENTION

The present invention aims at the provision of an improved diesel fuel injection nozzle, based on the air injection principle, which is capable of finely atomizing and vaporizing the fuel and intimately mixing it with air to provide optimum combustion in engine cylinders. The invention also seeks to eliminate the need for bulky and expensive equipment conventionally required for injection air.

The improved diesel fuel injection nozzle according to this invention includes a plunger reciprocably mounted in a nozzle body and defining in combination therewith an air chamber for receiving compressed air from the combustion chamber of a diesel engine cylinder. The plunger reciprocates simultaneously with a valve member which is also mounted in the nozzle body and which defines in combination therewith a fuel chamber for receiving fuel to be injected. Both the air chamber and the fuel chamber communicate via suitable passages with a premixing chamber which is directly open to the combustion chamber of the diesel engine cylinder through a spray hole.

The air chamber receives compressed air from the combustion chamber through the premixing chamber during the compression stroke of the piston in the engine cylinder, whereas at the same time the fuel chamber receives fuel under relatively low pressure from a suitable fuel supply. As the plunger is pressed in a direction to reduce the capacities of the air and fuel chambers at the end of the compression stroke, the charge of fuel in the fuel chamber is expelled by the valve member into the premixing chamber, where the fuel is atomized by and mixed with the high speed streams of highly compressed air from the air chamber. The fuel thus premixed with the compressed air is then injected into the combustion chamber in a fine spray to ignite the compressed air therein.

Essentially, the premixing chamber forms a flow path of the highly compressed air from the air chamber back into the combustion chamber, and the fuel is forced into this flow path of the compressed air from the fuel chamber through restricted passages or orifices. The fuel can

therefore be finely atomized and vaporized and intimately mixed with the air under pressure as it flows from the premixing chamber into the combustion chamber. It is particularly noteworthy that the invention utilizes the compressed air from the combustion chamber for atomizing and vaporizing the fuel prior to its injection into the combustion chamber, thus dispensing with any external source of such air.

The above and other objects, features and advantages of this invention and the manner of attaining them will become more apparent, and the invention itself will best be understood, from the following description and appended claims taken in connection with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an axial sectional view of the diesel fuel injection nozzle constructed in accordance with the present invention, shown together with a fragmentary section of a diesel engine cylinder into which the fuel is to be injected by the nozzle;

FIG. **2** is a fragmentary, axial sectional view of a modified diesel fuel injection nozzle in accordance with the invention;

FIG. **3** is a plan view of a ring member incorporated in the modified nozzle of FIG. **2** to impart spiral motion to the compressed air, and therefore to the fuel, to be introduced into the diesel engine cylinder; and

FIG. **4** is a fragmentary, axial sectional view of another modified diesel fuel injection nozzle in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be described more specifically in terms of a first preferred embodiment thereof illustrated in FIG. **1**. Generally designated **10**, the fuel injection nozzle according to the invention is therein shown mounted in position on a diesel engine cylinder **12**. The nozzle **10** comprises a body **14** of substantially cylindrical or tubular shape, a cap **16** held against the bottom surface **18** of the nozzle body, and a nozzle tip **20** enclosing the cap. A nozzle retainer nut **22** holds the nozzle body **14**, the cap **16** and the nozzle tip **20** in the relative positions described and secures them to a nozzle holder, not shown, by making threaded engagement therewith. Although the nozzle body **14** and the cap **16** are shown as separate units, the cap should be considered integral part of the nozzle body for the purposes of the invention.

The nozzle body **14** has a bore **24** formed axially therethrough. Slidably mounted in this bore for up-and-down reciprocation is a plunger **26** which is shown to be formed integral with a needle valve **28** of reduced diameter extending downwardly therefrom in axial alignment, with a shoulder **30** formed therebetween. Between this shoulder and the opposed top surface **32** of the cap **16** there is defined an air chamber **34** for receiving compressed air from the combustion chamber **36** of the diesel engine cylinder **12**. The needle valve **28** is slidably fitted in a bore **38** in the cap **16** to define a fuel chamber **40** in communication with a suitable diesel fuel supply, not shown, by way of a passageway **42** and a fuel inlet **44**. The fuel can be delivered to the fuel chamber **40** under relatively low pressure.

The plunger **26** together with the integral needle valve **28** is normally held in a raised position, as illus-

trated, by a spring, not shown. The plunger-valve combination is to be pressed against the force of the unshown spring by a suitable actuating mechanism such as a rocker arm and pushrod driven by the engine camshaft. The actuating mechanism is also not shown because of its rather conventional nature.

The nozzle tip **20** defines a substantially funnel-shaped premixing chamber **46** in combination with the cap **16**. In this premixing chamber the fuel from the fuel chamber **40** is to be intimately premixed with and finely atomized by the compressed air from the air chamber **34**, prior to injection into the combustion chamber **36**. Thus the premixing chamber **46** communicates with the air chamber **34** via a plurality of angularly spaced, parallel passages **48** and with the fuel chamber **40** via a plurality of small diameter passages or orifices **50**. A spray hole **52** in the nozzle tip **20** directly communicates the premixing chamber **46** with the combustion chamber **36**. It should be noted that the orifices **50** are open to the premixing chamber **46** at points intermediate the ends of the premixing chamber with respect to the flow of the compressed air therethrough from the passages **48** to the spray hole **52**.

The reference numeral **54** designates the cylinder block of the diesel engine under consideration. The cylinder **12** formed in the cylinder block **54** has a piston **56** reciprocably mounted therein so as to define the combustion chamber **36**.

In operation, let it be assumed that the plunger **26**, as well as the needle valve **28**, of the fuel injection nozzle **10** is now in the illustrated raised position, and that the piston **56** in the engine cylinder **12** is lowered, ready to start travelling upwardly on its compression stroke, also as depicted in FIG. **1**. The diesel fuel is delivered under relatively low pressure from its unshown source to the fuel chamber **40** via the inlet **44** and passageway **42**, to be temporarily stored therein, while the plunger **26** is raised. Also, as the piston **56** travels upwardly on the compression stroke, part of the compressed air in the combustion chamber **36** flows into, and is temporarily stored in, the air chamber **34** via the spray hole **52**, premixing chamber **46**, and passages **48**.

The plunger **26** is pressed down by the unshown actuating mechanism at the end of the compression stroke. Descending with the plunger **26**, the needle valve **38** forces the diesel fuel in the fuel chamber **40** out into the premixing chamber **46** via the orifices **50**. The plunger itself also expels the compressed air from the air chamber **34** into the premixing chamber **46** via the passages **48** at high speed. Thus in the premixing chamber the high speed streams of compressed air atomizes and intimately mingles with the fuel issuing from the orifices **50**. The fuel-air mixture is subsequently sprayed from the spray hole **52** into the combustion chamber **36** of the engine cylinder **12**, therein to be ignited by the air compressed to a high temperature.

It should be appreciated that the compressed air in the air chamber **34** undergoes further compression and a consequent temperature rise when forced out into the premixing chamber **46** by the descending plunger **26**. Such high temperature air promotes the vaporization of the fuel in the premixing chamber. Further the air streams from the air chamber **34** have such high speed that the fuel can be thoroughly mixed with the air and injected into the combustion chamber in a fine spray. Still further, for all these advantages offered by the high speed streams of air under pressure, the invention requires no source of such air external to the engine proper.

FIG. **2** illustrates a modified diesel fuel injection nozzle **10***a*, which incorporates a ring **60** mounted within the nozzle tip **20** and encircling part of a cap **16***a* of slightly modified shape. As better seen in FIG. **3**, the ring **60** is configured to define spiral passages **62** through which air passages **48***a* in the cap **16***a* communicate with the premixing chamber **46**. The other details of construction of this modified nozzle **10***a* can be essentially identical with those of the nozzle **10** of FIG. **1**.

Thus, as the plunger is depressed at the end of each compression stroke, the passages **62** in the ring **60** function to impart spiral motion to the compressed air flowing therethrough from the air chamber **34** to the premixing chamber **46**. The sprial flow of the air in the premixing chamber serves to increase the relative velocities of air and fuel streams and to give spiral motion to the fuel as well. The fuel can therefore be more intimately mixed with the air, and atomized to a still higher degree, before entering the combustion chamber.

FIG. **4** gives another modified diesel fuel injection nozzle **10***b*, which is analogous with the nozzle **10** of FIG. **1** except for an annular ridge **64** formed on the inside surface of the nozzle tip **20** and in the vicinity of the orifices **50**. This annular ridge is intended to create a restriction **66** in the premixing chamber **46**. The restriction **66** serves to increase the velocity of flow for more favorable spraying of the fuel-air mixture into the combustion chamber, by the venturi effect.

The foregoing description of some specific embodiments is meant purely to illustrate or explain and not to impose limitations upon the invention, since various modifications or alterations of the invention may be resorted to within the proper scope of the invention. For example, the spiral air passages of FIGS. **2** and **3** may be combined with the premixing chamber restriction of FIG. **4** in a single diesel fuel injection nozzle.

What we claim is:

1. A fuel injection nozzle for the delivery of fuel, premixed with air under pressure, to the combustion chamber of a diesel engine cylinder, comprising:

(a) a nozzle body;

(b) a plunger reciprocably mounted in the nozzle body and defining in combination therewith an air chamber for receiving compressed air from the combustion chamber of a diesel engine cylinder;

(c) a valve member formed integrally with and reciprocable simultaneously with the plunger in the nozzle body, the valve member and nozzle body defining in combination a fuel chamber for receiving fuel to be injected;

(d) means defining a premixing chamber open to the combustion chamber of the diesel engine cylinder;

(e) there being passages communicating the air chamber and the fuel chamber with the premixing chamber, so that the fuel from the fuel chamber is injected into the combustion chamber after being premixed in the premixing chamber with the compressed air from the air chamber.

2. A diesel fuel injection nozzle according to claim **1**, wherein the premixing chamber is substantially funnel-shaped.

3. A diesel fuel injection nozzle according to claims **1** or **2**, wherein the fuel chamber communicates with the premixing chamber via a plurality of orifices.

4. A diesel fuel injection nozzle according to claim **3**, wherein the orifices are open to the premixing chamber

at points intermediate the ends of the premixing chamber with respect to the flow of the compressed air therethrough.

5. A diesel fuel injection nozzle according to claim **1**, wherein the valve member is a needle valve in axial alignment with the plunger.

6. A diesel fuel injection nozzle according to claim **1**, further comprising means for imparting spiral motion to the compressed air flowing from the air chamber to the premixing chamber.

7. A diesel fuel injection nozzle according to claims **1** or **6**, wherein the premixing chamber has a restriction for increasing the velocity of the premixed fuel and air.

8. A diesel fuel injection nozzle according to claim **1**, wherein the premixing chamber is substantially funnel-shaped, wherein the fuel chamber communicates with the premixing chamber via a plurality of orifices which are open to the premixing chamber at points intermediate its ends with respect to the flow of the compressed air therethrough, and wherein the premixing chamber has an annular restriction formed in the vicinity of the orifices for increasing the velocity of the premixed fuel and air.

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